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upon invertebrate palæontology than that of the Brachiopoda. For this reason mention should be made here of a memoir by Prof. W. K. Brooks, on the "Development of *Lingula* and the systematic position of the Brachiopods," published in Scientific Results for 1878, Chesapeake Zoölogical Laboratory, Johns Hopkins University, Baltimore, 1879. Prof. Brooks opposes the views so long and ably advocated by Prof. Morse, that the Brachiopoda are specialized worms, and presents his reasons for regarding them as more nearly related to the Polyzoans.

The foregoing notes, so far as is known, embrace all the publications that come within the scope of this article. There are, doubtless, other works in progress whose authors are waiting suitable opportunity to pursue their investigations. Prof. A. R. Grote has some uncompleted and unpublished notes on a new form of the remarkable crustacean genus *Eusarcus* Grote and Pitt, in the Waterlime group of Western New York. Prof. Verrill has also in hand the few fossils that were dredged from the submerged Tertiary beds off the north-eastern coast, but nothing has been published concerning the fauna of this Tertiary Atlantis since his article of last year in the *American Journal of Science and Arts*.

It has often been a subject of remark during the past few years that invertebrate palæontology was receiving comparatively little attention in the United States, but the foregoing makes a very satisfactory showing for the past year. The excellent character also of much of the work that is being done by the younger palæontologists promises well for the future.

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A REVIEW OF THE MODERN DOCTRINE OF EVOLUTION.—CONCLUDED.[1]

BY E. D. COPE.

III. Metaphysics of Evolution.

I ENTER here upon a wide field, over which I can only skim on an occasion like the present. The subject has been already introduced by reference to consciousness as modifying movement; of course then if movement modify structure, the latter is influenced by consciousness. The word consciousness was then, and is now, used in its simplest sense, viz: as synonymous with physical sensibility. Its lowest and most usual exhibition is the sense of touch; the special senses, taste, sight, etc., are higher forms, while thoughts and desires are organized products of the same raw material. Consciousness cannot be denied to many of the inferior animals; indeed, if we grant it to any, we must admit that it is displayed at times by even the lowest *Protozoön*. That these humble creatures should possess it, is apparently quite as probable as that the very similar bioplasts of the brain of man should be its seat.

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[1] A lecture delivered before the California Academy of Science, Oct. 27, 1879.

Consciousness alone is not a sufficient basis for the development of mind. For this, one more element is necessary, and that is, *memory*. Impressions made by the environment are registered, and soon cease to be present in consciousness. Under the influence of association the impressions return to consciousness. Associations are those of place, of the order of time, and of similarity or difference in various qualities, as size, color or any other physical features. Experiences of these qualities are to all conscious beings either painful, indifferent or pleasurable. When association requires, events, objects or characteristics, are returned to consciousness in the order in which they cohere most firmly in the mind, which may or may not be that in which they entered it. The liking for or dislike to the object, are equivalent to an attraction to or repulsion from it. Thus experience is begotten: as its material increases, new combinations are formed, new relations observed, and in the highest types of mind, laws are discovered. No one can deny memory to animals; it is the medium of their education by man, and has been as well the means of their education by nature. Impressions cause a rearrangement of certain elements of structure which give the form to consciousness when it arises again. It is also probable that these arrangements are not the same as those which represent classifications and conclusions, but that nevertheless the arrangement or organization of these is determined by the simpler arrangements caused by perceptive stimuli. Experience produces these combinations in the bioplastic aggregations of all animals, be they in the form of ganglia, brains, or less specialized forms. Nowhere in the human organism are the effects of effort and use so strikingly witnessed as in the increase of brain power; and familiarity with the education of the lower animals shows that this is the case with them also, though in a lesser degree than in man.

If, then, we grant the propositions, first, that effort and use modify structure; and second, that effort and use are determined by mind in direct ratio to its development, we are led to the conclusion that evolution is an outgrowth of mind, and that mind is the parent of the forms of living nature. This is, however, to reverse a very usual evolutionary hypothesis, viz: that mind is the product and highest development of the universe of matter and force. The contradiction is, however, not so absolute as at first appears. By mind, as the author of the organic world, I mean only the two elements, consciousness and memory. But it is the view of some thinkers that consciousness is a product; that it is not only a correlative of force, but a kind of force. To the latter theory I cannot subscribe; when it becomes possible to metamorphose music into potatoes, mathematics into mountains, and natural history into brown paper, then we can identify consciousness with force. The nature of consciousness is such as to distinguish it from all other thinkable things, and it must be ranged with matter and force as the third element of the universe.

It is true that unconsciousness does not imply absence of life as generally understood. A majority of the processes of life are performed unconsciously by living creatures; mind itself being no exception to this rule. There is another class of acts whose performance produces sensation, but consciousness is not concerned in them as an immediate cause. Therefore, it is a common endeavor to associate reflex and unconscious acts with the molecular movements of inorganic and non-living substances. But the one great difficulty in making this identification has never been surmounted. This is the different nature of the movements in the two cases. In non-living matter they are simply polar, nothing more. In living beings they display design. Perhaps I use the word "design" in a new sense, but the expression is nevertheless appropriate. What I mean is, that the movements of living things have direct reference to consciousness, to the satisfaction of pleasures, and to the avoidance of pains. The *molecular* movements within animals of the simplest class are the digestion of food and the elaboration of the materials of reproduction. The *molar* movements of the simplest animals are to enable them to escape the pains of hunger and celibacy. Moreover there is reason why the movements of living beings display design. We all know the nature of habits; how they are performed unconsciously, and as automatically as digestion itself. But did any one ever know of a habit in an animal, whose origin he could trace, which has been formed in unconsciousness? According to our knowledge, habits are always the result of stimuli which are consciously felt, and which cause by repetition or through reminiscence a repetition of the resulting movement. After a sufficient number of repetitions such an act becomes a habit, *i. e.*, is performed automatically, or without the intervention of effort, and frequently without consciousness. It thus becomes a part of the character of the individual or species. This common phenomenon is explained by the hypothesis, that an organization of the centers controlling action is caused by the efforts of the animal under the stimulus, and that finally a machine is constructed which determines the nature of the force expended, without further mental exertion of the individual. Such a process is education, and the result is an addition to the stock of faculties already on hand. Thus is explained the vast number of automatic and unconscious activities displayed by animals; to the same source, I believe, the common reflex acts may be traced; it even appears to me probable that the organic functions in general have had the same origin.[1] While these latter have mostly long since passed beyond the control of the mind, portions of the urogenital functions still linger within the confines of its jurisdiction. Thus have consciousness and mind endowed living nature with useful functions; and this, which may be called the *Theory of Endowment*, accounts for the element of design which is so puzzling when seen in unconscious and reflex acts.

As it has been maintained above, that structure is the effect of the control over matter exercised by mind, it is evident that the evolution of mind must be directly followed by corresponding development of organism. The science of palæontology substantiates this theory in a wonderful manner. But the animal mind being generally occupied with simple functions, its expressions in structure are usually nothing more than the progressive creation of improved instruments for obtaining food, resisting climate, escaping enemies, and reproducing their kind. The struggles of animals have been on this platform, and mind has only been necessary to aid in accomplishing the ends above mentioned. Wonderfully effective machines for grinding, cutting, seizing and digging; for running, swimming and flying have been produced. The development of mind proper must appear in the size and structure of the brain; and though the history of the latter in past ages must always remain, in large part, hidden from us, it is known that in the former respect there has been great progress made in various lines of animals. Now the line which has carried brain to its present development in man, the *Quadrumana*, has been deficient in special mechanical excellencies of the kind enumerated above. Perhaps primitive inferiority in these many respects has kept the *Quadrumana* under greater mental tension, and compelled them to exercise caution in their acts and give that opportunity to thought which was less demanded in the case of other animals. Furthermore, if they are less specialized in their mechanism than most other *Mammalia*, they are less restricted by it to peculiar modes of life. They are more versatile, and more capable of the adoption of new habits as a consequence. And here we have a glimpse of a most important principle in evolution, which is the keynote to its method; this is what I have called *The Doctrine of the Unspecialized.*

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[1] Consciousness in Evolution. *Penn Monthly*, 1875.

Palæontology shows that the succession of living types has not been in a single straight line. It has been in many divergent lines, and a large number of them have not continued to the present time. The history of life has been well compared to a tree with divergent branches, many of which do not reach the elevation of the summit. Furthermore, in the many cases in which we can trace the lower lines to the present period, it is evident that in their present condition they could not have given rise to the higher forms. Each line, in fact, has developed to an extreme of specialization of structure, which it would seem is incapable of modification in any direction very divergent from that which it has already taken. Much less have such specialized types been able to survive the environment for which they were designed; with important changes in that respect they have perished. A few examples will serve to illustrate my meaning. The direction of development has been from fishes, through *Batrachia* and reptiles, to birds and mammals. But we cannot derive any living type from the osseous fishes of the present or past ages *(Hyopomata)*: to find the origin of *Batrachia*, we must pass below these to more generalized and older forms, the *Dipnoi*, a class whose position in the system was for years a controverted point. We cannot obtain *Mammalia* from any of the existing types of reptiles, but we must go back to the Permian period, and trace their outlines in the *Theromorpha* of that day. In spite of the prophetic resemblance of these remarkable animals, they are inferior to later Reptilia in the structure of their vertebral column, and display resemblance to some of their immature stages, as well as to those of the *Mammalia*. Among mammals we cannot derive monkeys from *Carnivora* or *Ungulata*, nor the latter from each other, but can only trace their close approximation in the Bunotherian types of the Lower Eocene. So with the great divisions of *Ungulata; Proboscidians*, *Hyrax*, and the even and odd-toed orders must all be traced to the unspecialized *Amblypoda*, with small brains and five-toed plantigrade feet, as their ancestors.[1] It is easy to perceive that the generalization and plasticity of all these forms has furnished the ground of their ancestral relation.

We are now in a position to comprehend more clearly the general nature of evolution. The doctrine of the unspecialized teaches that the perfection produced by each successive age has not been the source or parent of future perfection. The types which have displayed the most specialized mechanism have either passed away, or, undergoing no change, have witnessed the progress and ultimate supremacy of those who were once their inferiors. This is largely true of animals which have attained great bulk. Like those with perfected weapons, they have ever been superior to the attacks of other animals in their day, and doubtless led, so long as food abounded, lives of luxurious indolence. With change or diminution of food, such huge beasts would be the first to succumb, and it is a fact that no type of land animals has maintained great size through many geologic changes. It is true that all of the lines of ancestry of the existing higher *Mammalia*, as the subdivisions of the *Carnivora*, *Ungulata* and *Quadrumana*, which we know in detail, commenced with types of small size and correspondingly little muscular power.

Some important conclusions may be derived from what has preceded. It seems that evolution has witnessed a continual running down of types to their great specialization or extinction. That many types have arisen in weak and small beginnings, but that the conflict with more powerful forms has developed some qualities in which they sooner or later excelled, and which formed the basis of their future superiority and persistence. That while this has probably been the true cause of the origin of the many admirable mechanical adaptations displayed by animals, it is preeminently true of the development of mind. That the reason why progress has reached its limit in the lines of greatest specialization, has probably been the removal of the occasion of its original cause, *i. e.*, active exercise in the struggle for existence. This explanation is suggested by the remarkable degradation which is witnessed in animals whose mode of life relieves them from the necessity of working for a livelihood, *e. g.*, the parasites and sessile animals whose young are free. Some of these creatures, on assuming their parasitic life, lose the semblance of even the order to which their young belong. The primary stages of various plants move actively through the water like the lowest forms of animals, and their sessile adult condition must be looked upon as a degeneration. It is well known that the endeavor to relegate the lowest forms of life to the two kingdoms of animal and vegetable, has been generally abandoned. The great vegetable kingdom probably exhibits a life degraded from more animal-like beginnings. Animal irritability and mobility have been lost, and their own consciousness must be entirely eliminated from the question of the origin of the many later and specialized types of plants. But I venture here the hypothesis that the consciousness of plant-using animals, as insects, has played a most important part in modifying the structure of the organs of fructification in the vegetable kingdom. Certain it is that insects have been effective agents in the preservation of certain forms of plants. I would suggest whether the mutilations and strains they have for long periods inflicted on the flowering organs, may not, as in some similar cases in the animal kingdom, have *originated* peculiarities of structure.

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[1] See the origin of types of *Mammalia educabilia*, Journal Academy, Philadelphia, 1874. This view was subsequently expressed by Huxley.

Evolution of living types is then a succession of elevations of platforms on which succeeding ones have built. The history of one horizon of life is, that its own completion but prepares the way of a higher one, furnishing the latter with conditions of a still further development. Thus the vegetable kingdom died, so to speak, that the animal kingdom might live; having descended from an animal stage to subserve the function of food for animals. The successive types of animals have first stimulated the development of the most susceptible to the conflict of the struggle for existence, and afterwards furnished them with food. Doubtless in the occupation of the world's fields, the easiest and nearest at hand have been first occupied, and successively those which were more difficult. The digging animals are generally those which first abandoned the open field to more courageous or stronger rivals; and they remain to this day generally of low type compared with others of their classes (*e. g.*, *Monotremata*, *Rodentia*, *Insectivora*). All occupations have been filled before that one which requires the greatest expenditure of energy, *i. e.*, mental activity. But all other modes of life have fallen short of this one in giving the supremacy over nature.

Automatism then represents a condition of "lapsed intelligence" and diminished life. The unconscious automatism of animals is a condition of still greater lapse. On the contrary, sensibility is the condition of development, and the susceptibility and impressibility which is the extreme reverse of automatism is the especial character of youth. Here the "doctrine of the unspecialized" finds justification again.

What the future has in store for us in the history of inorganic force and its results, we can not now foresee, but I call attention in this connection to the important part played by life in the distribution of minerals. It has long been known that the carbon of the earth's crust was once in a living state, and it is admitted that the limestone once circulated in the fluids of animals. We have recently been compelled to believe that siliceous rocks are composed of the consolidated shells of minute plants, which they have elaborated from the water of the ocean. Silver and gold are segregated and deposited by seaweeds. The principal rock material, whose relation to life has not been ascertained, is alumina. How far the processes which now characterize dead matter were once related to life is a problem for the future.

IV. The Morals of Evolution.

The doctrines of the struggle for existence and survival of the fit in human life, have a two-fold application. The relative proportions in which these applications are made, will depend on the moral development of him who makes them. Moral density and intelluctual stupidity (often nearly allied) will see in these two laws only the struggle for material power, and the survival of the strongest. They will hardly urge in these days, as they would infallibly have done had they lived a few centuries ago, that the strongest means the hardest hitter, or the most successful assassin, but they will probably believe that this pre-eminent position belongs to the most wealthy. From a purely dynamical standpoint this position is correct, yet it might be a useful question for such advocates to consider why it is that physical oppression and assassination should be less successful avenues to power than they once were.

There are two reasons why man does not grant the first place in his esteem to physical force. The first principles of morals are acquired in the struggle for existence. The idea of *meum* and *tuum* was speedily developed so soon as men associated together; and the habit of justice has doubtless been formed by the insistence of every man on his own rights, and by the power of combinations of men to control those who may from superior strength or other cause seek to violate the rights of property. Thus law originated, and from the earliest history of the race to the present day it has educated the barbarous and semi-barbarous to civilization. It is then easy to perceive that man gives the highest place in his affections to the *most just;* but there is yet another reason why this should be the case.

The reproductive instinct in the lower animals has developed into social affections, and these form a part of the character of the higher animals and, in an especial degree, of man. The sentiments of sympathy and benevolence are probably outgrowths of the same. While the rational faculties are concerned in the *knowledge* of right, these sentiments are a source of the *love* of right. This disposition is trusted by men as leading to the *practice* of right, in cases where the power to enforce it is not immediately present. The struggle for existence then among men ranges all the way from a rivalry of physical force to a rivalry for the possession of human esteem and affection. The robber and assassin of the lowest human races are represented by the slanderer and defamer in the higher. The ultimate prosperity of the just, asserted and foretold by prophets and poets, is but a forecast of the doctrine of the survival of the fittest. The unjust are sooner or later eliminated by men from their society, either by death, seclusion or ostracism.

But the organized moral qualities cannot normally transcend in power, as motives of human action, those which secure his physical preservation. Lines of men in whom the sympathetic and generous qualities predominate over the self-preservative, must inevitably become extinct. Evolution can produce no higher development of the race (whatever may sometimes appear in individuals), than an equivalency in these two classes of forces. Beyond this the organization of the social faculties of the brain must always be repressed in the race, so that we can only expect to attain an equilibrium between them and the more purely selfish ones, as the very highest result of unassisted evolution. In this position the judgment is suspended between the opposing classes of motives; and it must ever remain doubtful in general as to whether resulting action will be just and right, or the reverse. I exclude from this question those generous acts which do not appear to the actor to conflict with self-interest. These may be termed *sympathetic* acts, and are quite distinct from the altruistic.[1] The sympathetic actions are seen at times in most animals. The altruistic acts, on the other hand, are those that express what is usually called " moral principle." Such acts may often coincide with the interest of the actor, but so long as they do not appear to him to do so, they are altruistic. It is part of the doctrine of evolution, that habits will ultimately disappear on the removal of their stimulating cause. The moral nature originated, and has been maintained, through the pressure of the fear of consequences. The removal of this pressure, through the acquisition of power, would then ultimately result in the diminution or loss of the moral nature, through disuse. The abuses of power are well known. This appears to be all that evolution can do for us in the production of the moral nature. So it would appear that no organized faculty of *self-sufficient altruistic justice* can be derived by the process of mental evolution. The result is rather a continued struggle between justice and injustice. It is, then, evident that any power which shall cause the permanent predominance of the just over the selfish faculties must be derived from without.

After we omit from customary religion, cosmogony, which belongs to science, and theogony, which belongs to the imagination, we have left an art which has for its object the development and sustentation of good works or morals among men. If the teachers and professors of this art produce the results in this direction at which they aim, their great utility must be conceded by all. Their method has the advantage over that of the law, in being of the character of inducements supplied before action, instead of pains and penalties inflicted after action. They strive to *originate* good conduct, rather than to punish bad conduct. They are working on the side of the *originative* force in development, rather than the destructive; the "*origin of the fittest,*" rather than the "*survival of the fittest.*" Whether man possesses the spontaneous power called "free will" or not, the work of supplying inducements for good conduct is most useful to society. But religion, as generally understood, pre-supposes free will; and the definition of the word responsibility implies its existence. The question as to the presence of such a faculty is an interesting one, and will now be briefly considered.

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[1] On the Origin of the Will. *Penn Monthly*, 1877.

The well-known doctrine of necessity leaves no place for free will. All acts are the consequences of motives, and are the outcome of a balancing of interests. The heaviest side of the account determines action. Our physical necessities supply the motives for most of our activities; our pursuit of food and clothing is of necessity, and no condition is free from it. Evolution supports and explains this doctrine, as can readily be perceived. It derives our instincts from an ancestry whose daily occupation has been their gratification. But it has been shown above that this development does not supply the motives of an independent morality.[1]

The direction of action under stimulus is determined by intelligence, which is, as has been above maintained, the product of experience. Intelligence is organized or classified knowledge, and directs the activities set on foot by the likes and dislikes, that is, the affections. *When there is knowledge, there is no necessity for spontaneous action or free will,* since action is determined by the organization of the mind. Even if the mind is conscious of insufficient knowledge, an inducement to seek knowledge is supplied, and according to the result of investigation will be the direction of knowledge.

But we are here brought to face the case where knowledge cannot be or is not obtained. This is the condition of the two questions of the practice of morals, and the nature of the future life. The evolution of mind consists of a continual advance from the known into the unknown, and a transfer of the unknown to the known. So long as there is any inducement to progress of this kind, and nature responds to inquiry, development will go on. Although it is true that it is only among men, and but few men at that, that the pursuit of knowledge is an occupation; most men add to their stock incidentally as they pursue other avocations. The knowledge of right and the inducements to its practice are learned in their every-day intercourse, so far as it can be acquired. But knowledge in these directions soon attains its limit, and accordingly, development dependent on knowledge must cease. If any further progress in practical morals is to be made, some new force must intervene at this point.

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[1] On the Origin of the Will. *Penn Monthly*, 1877.

Here is the opportunity for the appearance of will or spontaneity; here it is at least needed. I am willing to believe that it may appear at this point, and that so long as we have to face the unknown in moral progress, so long it will remain. As a force it must be equivalent of other forces, but as a form of consciousness it is a new element of mind. As represented in new molecular organization, it may always continue, even after much of the unknown may have been conquered, and a stationary period may have ensued. Such an accession to character would be a fitting crown of evolution, and a justification of this labor of the ages. If a true factor in human development, it might be compared, in the creation of character, to the apical bud of a growing tree. As the part preëminently living, it leads the growth of the trunk and branches. They all follow of necessity the path it has marked out. Under its lead they are successively formed, become fixed, and finally decay.

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THE TONGUE OF THE HONEY BEE.

BY PROF. A. J. COOK.

THE bee is, and has long been, of great importance to the commercial world, and this, together with the fascination inseparable from its study, have led many of the ablest scientists to carefully investigate its structure and habits. Yet I know not if there exists to-day an accurate description of a bee's tongue, and the method by which the insect procures its food.

The literature of the subject abounds in confusion and inac-